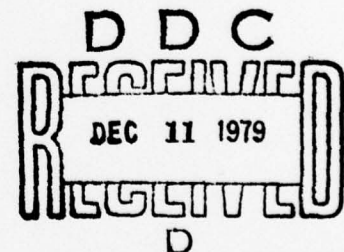# LEVEL

HELICOPTER PILOT DETECTION OF TWO DIFFERENT CAMOUFLAGED HAWK BATTERIES

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CAMOUFLAGED HAWK BATTERIES

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INTRODUCTION

The purpose of this study was to collect data comparing the camouflage effectiveness of the cage-supported light-weight camouflage screen (LCS) and the experimental shape disrupter system produced by the Mobility Equipment Research and Development Command (MERADCOM). The camouflaged Hawk battery systems were contrasted with a control Hawk battery having no camouflage. The data reported in this paper were collected by ARI for use by the US Army Air Defense Board (ADB) as part of a larger scale study for the US Army Air Defense School (USAADS).

ARI was specifically tasked with determining the human pilot detectability of the batteries in contrast to other portions of the study dealing with satellite and photoimagery interpretations. Originally pilots of both low and high speed aircraft were to be utilized. Scheduling problems precluded the latter. Consequently, the data presented refer only to helicopter pilots and the associated Hawk ground crews. Several originally planned sources of data were not actually collected due to changes in the exercise after the initial plan had been drafted. These include detection times and controlled deployment areas for the batteries. Nonetheless, the data that were collected appear to consistently support one camouflage system over the other.

METHOD

SUBJECTS

The subjects consisted of 20 helicopter pilots working in pairs drawn from the 3rd Armored Cavalry Regiment and 160 ground troops drawn from the 5th battalion of the 57th Artillery Unit. A Battery served as crew for the LCS deployments, B Battery was in charge of the Disrupter System. It should be noted in passing that severe personnel constraints required drastic limitations be made on all sizes within the experimental design. This resulted in a marked loss of experimental test power.

EQUIPMENT

A ground-to-air radio net was used to call in map coordinates once pilots had located the sites. Range and azimuth of the helicopter was also provided sporadically by IPAR, IHIPIR, or IFF returns. Pilot and ground crews were debriefed through questionnaires and structured interviews provided by ARI.

PROCEDURE

Two improved Hawk batteries (less one firing section each) were tactically deployed under one of three possible conditions: 1) without camouflage (clean site), 2) with LCS, 3) and with shape disrupters.

The exercise took place over four days. On the first two days pilots searched for both the LCS and disrupter system. On the last two days only the clean site was deployed. Each site was located within a different 6 sq. kilometer grid. Before beginning the search pilots were briefed as to the grid they were to search and were instructed not to discuss observations with other pilots until the completion of the exercise. Pilots were then instructed to fly to a standard starting point to begin the exercise. Upon lifting off from the predetermined area, pilots entered a nap-of-earth (NOE) search mode continuing until a site observation was made or fuel ran low. On observing the site, pilots called in their map coordinates which were recorded for later use in establishment of detection distances.

Pilots then turned and proceeded to fly directly over the site in order to verify that they did in fact locate one of the batteries. Pilots then returned to their starting point. Upon landing, pilots were debriefed by ARI and administered a series of questionnaires regarding what they detected, where it was located, what pieces of equipment were identified, and what relevant cues permitted detection. After the exercise, the ground crew personnel were interviewed for comments and suggested improvements. Data were then screened, summarized, and subjected to statistical tests where feasible.

RESULTS

The results are best summarized in terms of a series of questions and answers. Due to changes in the planned exercise, certain data became irrelevant from that listed in the original study plan. With one exception, all sites were detected, thus invalidating comparisons between sites on the basis of proportion of hits or misses. In addition, pilots had apparently learned in advance that the sites were improved Hawk, invalidating the overall identification task except for observable cues on particular pieces of equipment. Most of the useful data concerned the analysis of cues that led to site detection along with interviews leading to suggestions for improvement of camouflage. This information follows:

FROM HELICOPTER PILOTS

Question 1: Were camouflaged sites any harder to detect than clean sites?
Responses: 6-yes 6-no 2-no response
Conclusion: Mixed results show that the extremely high detection rate invalidates the use of further proportional data.

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Question 2: What features aided you most in detecting each of the sites?
Responses are given by site name, feature, and percentage of total possible number of individuals responding with that cue.

LCS

Color of Net (69%)
Shape of Equipment (69%)
Obvious Location of Site (56%)
Break in Horizon (56%)
Unusual Size of Object (44%)
Deployment Configuration (19%)
Radar Rotation (13%)

Disrupter:

Color (94%)
Radar Rotation (63%)
Obvious Location (44%)
Deployment Pattern (31%)
Shape of Equipment (19%)
Unusual Size (19%)
Glare off Metal (13%)
Horizon Broken by Equipment (6%)

Clean

Personnel or Equipment Movement (81%)
Abnormal Coloring (44%)
Smoking Generators (44%)
Unusual Shape for Area (32%)
Visible against Horizon (31%)
Deployment Pattern (19%)
Obvious Location (12%)
Shadows (6%)
Unusual Size (6%)

Conclusions: The camouflage clearly affected the pilots' ability to see specific cues. Color was the most often quoted cue for the two camouflaged systems. Radar movement was the most obvious for the Disrupters and unusual shape for the LCS.

Ranked Cues. The reports did not give any specific way to compare between sites; consequently a set of cues were suggested based on previous research. Pilots were asked to rank these cues from most important (1) to least important (8). The cues and their ranks are:

CUE	LCS	Disrupter	Clean
Color	3	1	3
Size	2	7	6
Texture	5	5	7
Movement	7	4	2
Cues not noted to the system	6	8	5
Contour (shape)	1	2	1
Deployment pattern	4	3	4

In order to determine which camouflaged sites were perceptually the most similar to clean sites (most poorly hidden), Spearman rank-order correlations were computed between each site combination. This produced the following values:

Rho (cage net versus disrupter) = .42
Rho (cage net versus clean) = .45
Rho (disrupter versus clean) = .67

Conclusions: The ranked cues show for the disrupters that unnatural color was the most obvious cue. For the LCS, unusual shape was most obvious. The rank order correlations also show that the Disrupters overall were ranked as the most similar to clean sites. This implies they were also the poorest as far as camouflage effectiveness was concerned. The Rho value between disrupter and clean site is significant at alpha = .05 (t = 2.02, one tailed test).

Least Useful Cues. In order to determine if any of the experimenter-chosen cues were erroneous, pilots were asked to list those cues they would consider of minimal utility. This information was useful for determining which cues did not contribute to the detection of a particular site and, by inference, which cues were well hidden. For all three sites reflection and texture were deemed of little value. For the remaining cues, the breakdown was as follows with the percentage of maximum possible response listed after each cue.

LCS		Disrupter		Clean	
Extraneous features	(43%)	Extraneous features	(25%)	Color	(12%)
Equipment movement	(31%)	Movement of people	(19%)	Configuration	(6%)
Color	(19%)				

Conclusions: Almost all the features were useful against an uncamouflaged site. The LCS did the best job of masking movement, reflectivity, and color.

<u>Detection Distances</u>. In order to determine detection distances, map coordinates were converted into kilometers from the site using the Pythagorean theorem. These points were then screened, discarding those values exceeding $\pm$ 1.5 standard deviation units from the mean, to reduce data noise. The screened data were then analyzed to acquire mean detection distances. Mean values were used in multiple t-tests to see if the detection distances were significant. The low sample size should be kept in mind in generalizing those results beyond the present conclusions. Number of data points is given in parentheses after mean values.

<u>Site</u>	<u>LCS</u>	<u>Disrupter</u>	<u>Clean</u>
Average detection distance			
$\bar{X}$	1.82 km (6)	2.94 (7)	2.56 (7)
S.D.	.45	.83	.84

t-test values and significance for two-tailed tests were as follows:

t LCS versus disrupter = 2.95 alpha = .02
t disrupter versus clean = .85 not significant
t LCS versus clean = 1.9 alpha = .10

<u>Conclusions</u>: The LCS was clearly the hardest site to detect. It was significantly better hidden than the disrupter. It was only marginally better than the clean site. This is probably due to error variance in detection distances. Taken together with the other results, it appears clear that the LCS was the superior camouflage for detection from helicopters flying NOE.

FROM GROUND CREW

<u>Question 1</u>: Do you feel either of the camouflages is of significant value?
<u>Responses</u>: 35-yes   13-no
<u>Conclusion</u>: Camouflage is of value even though it may not make a great difference.

<u>Question 2</u>: Do you feel either the LCS or disrupter is harder to detect than the other?
<u>Responses</u>: 34-yes   14-no
Of those saying yes 20 said LCS was harder to detect, 6 said disrupter; 8 did not respond.

<u>Question 3</u>: How would you improve either camouflage system?
(Number of responses given in parenthesis after each response)
<u>Responses</u>: a) Make disrupters more durable (6)
          b) Increase crew size deploying LCS (4)
          c) Test disrupters in weather (2)
          d) Increase exercise fidelity to wartime conditions (1)
          e) Make employment holes for disrupters more durable (1)

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LISTED COMMENTS FOR GENERAL IMPROVEMENT

From ground crew regarding LCS:

...not only does the cage take an excessive amount of time but it is also extremely hard for less than 12 people to assemble it.

...fiberglass poles going to metal poles don't make for any kind of fitting.

...putting up the side nets on the IPAR is extremely dangerous, even under the best of conditions.

...any type of strong wind would rip the nets apart.

...too time consuming to set up.

...LCS is better because it was easier to put up.

Ground crew regarding disrupter:

...the problem is with the place where the pins go through the holes to hold them in place; they are usually mashed and the pins can't go through. On the IPAR, if the brackets on the top of the radar had been mounted where they were at an angle no damage would have been done.

...they were so easy to damage; they're too fragile!

...bad weather would destroy it.

...the metal poles would bend or stick together.

...disrupters were extremely easy to detect (from ground).

...disrupters are better in that they save time and require fewer crew people.

...disrupters are easier to handle.

...disrupters are easier to put on equipment.

...disrupters are better because they stay in place better.

From helicopter pilots regarding LCS site:

...Site was first spotted from approximately 5 to 6 thousand meters but was not identified as a HAWK site until approximately 1000 meters due to the camouflage cover completely changing the shape of the objects.

...The color was darker than natural terrain features and didn't blend.

...Objects appeared to be large tents or buildings; blocklike shape silhouetted against the horizon.

...The objects broke up terrain features and broke the outline of the horizon.

...This site was easy to detect but harder to identify because it looked like buildings. Couldn't tell they were radars until we got close enough to see through the net.

...Camouflage could blend in with terrain if it is placed closer to dunes or thick vegetation.

...The edges on the camouflage shouldn't be so sharp. It seems that it would work better if it were located slightly below the surface for a smaller target.

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From helicopter pilots regarding disrupter:

    ...Color and shape of camouflage was definitely a giveaway. The color of the disruption was darker than the surrounding vegetation and was easily located because of its position close to a road.

    ...Color contrasted in the surrounding terrain; suggest a lighter color or mottled paint scheme on vehicles, also suggest wider netting to hide the changing profile or put disrupter nets over on the sides of the radar to keep the size from appearing to change with each rotation.

    ...The little umbrella shape camouflage had an unnatural look about them. It was not until we were within approximately 500 meters and flew directly over the site did I notice the little umbrellas being used for camouflage.

    ...Camouflage hid equipment from a distance but up close you could easily see the equipment.

    ...Rotation of radar gave site away; the movement was detectable from quite far away.

    ...There was a glare-reflection from the radar disk. This shiny object brought attention to the area, so did generator smoke.

From helicopter pilots regarding clean site (no camouflage):

    ...All three sites were easily detected by shape and color. The colors were darker and did not blend in with the surrounding terrain. They appeared to be angular or buildinglike objects that broke the outline of the horizon.

    ...Smoke, movement of radar screens were initial cues, color was also a large factor. Smoke from generators were detectable from as far as 4 to 6 thousand meters away.

    ...All sites were fairly easy to detect, the netted site, however, was hardest to determine as to what was actually there.

    ...Anything to hide the movement of the radar antenna would be an improvement.

    ...Vehicles were obviously larger than the dunes and other natural terrain features.

SUMMARY AND DISCUSSION

    Overall, the pattern of camouflage detectability became quite clear. The LCS system was harder to detect, requiring significantly closer distances to the sites. It did a better job of masking critical areas although on an absolute scale all three sites were easily detected. This may have been due to external problems such as poor choices of location and color mismatches with local terrain. It was also clear that radar antenna movement served as a primary cue for the disrupter site. The disrupter was also evaluated as quite fragile and subject to anticipated damage under true combat conditions. However, the disrupter was given good marks for the speed with which it could be set up.

The study itself was subject to certain contaminations which should be considered in generalizing the above results, even though they are statistically significant. In particular, pilots were very familiar with the search area, anticipating probable deployment sites and thus increasing detection probability for any site. Second, the results herein pertain only to slow speed helicopter detection and do not consider the full range of potential enemy threats. Also, since detection times were not recorded due to equipment failure the results may be biased with the time taken to observe a site, although this appears unlikely.

Site detection resulted mainly from color, radar movement, generator smoke, and unnatural contour. In general, the LCS did a more effective job of masking smoke, radar movement and contour. Color was poor for both sites but should be easy to adjust.